Massachusetts Flood Plain Management Services

MASSACHUSETTS NATURAL VALLEY STORAGE INVESTIGATION

December 1995

US Army Corps
of Engineers
New England Division

MASSACHUSETTS NATURAL VALLEY STORAGE INVESTIGATION

FOR
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
COMMONWEALTH OF MASSACHUSETTS

BY
NEW ENGLAND DIVISION
U.S. ARMY CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS 02254-9149

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MASSACHUSETTS NATURAL VALLEY STORAGE INVESTIGATION

1. INTRODUCTION

a. Purpose. The purpose of this study is to provide a technique for conducting an initial hydrologic evaluation of the potential for natural valley storage (NVS) in gaged or ungaged watersheds. The report attempts to provide guidance which would be used as part of an initial screening process to determine NVS potential. Additional evaluation and detailed analysis would then have to follow to allow for a complete evaluation of NVS within a particular watershed.

b. Authority. This study was conducted under the Corps of Engineers Section 206 Flood Plain Management Services (FPMS) Program, at the request of the Commonwealth of Massachusetts, Department of Environmental Management, and was performed by the New England Division of the Corps of Engineers.

c. Background. The method presented in this report is one of several tools which could be used in a preliminary screening to determine the potential of NVS based on peak discharges within a watershed. Prior to any detailed analysis, the U.S. Geological Survey (USGS) topographic quadrangle maps or other suitable mapping, such as land use, National Wetlands Inventory, or other wetland delineation sources, should also be reviewed to determine if there appears to be major storage areas within the watershed. These map sources also indicate the position of NVS areas within the watershed, which is an important consideration in any NVS analysis. Prior watershed studies may also be useful and should be investigated.

Detailed analysis of the NVS potential for a particular watershed requires the examination of flood hydrograph information for that basin. A hydrograph is a graphical representation of the time distribution of runoff at a given point in the basin. Typically, the presence of NVS will cause a lag and reduction in peak discharge between inflow and outflow. A hydrograph with quickly rising and receding limbs could indicate a lack of attenuation of flood waters in the watershed, often resulting from a lack of upstream flood storage.

Hydrograph information is one of the most useful indicators of NVS potential. Unfortunately, hydrograph generation can be time consuming and costly. The development of a hydrograph requires either site specific hydrologic data or the development of a mathematical rainfall-runoff model. Under either scenario, the development and analysis of hydrograph information requires a significant degree of hydrologic expertise. Peak discharge, however, is sometimes available and, while not providing a complete picture, it does provide some insight into watershed NVS potential and is the basis of the following analysis.

This report is presented in three sections. The first discusses development of the NVS screening technique. The second, "Application of Technique for Gaged Basins," gives guidelines for use of this technique in river basins where flood discharge records are available. The third, "Application of Technique for Ungaged Basins," provides guidelines for use of the technique in ungaged river basins where available information is limited to an estimated peak discharge or selected high watermarks.

NOTE: Additional site specific analysis may be required when hydrologic studies, estimated peak discharges, or high watermark information are not available.

2. TECHNIQUE DEVELOPMENT

a. General. Peak discharges are one indicator of potential NVS in a basin. High flood discharges (in comparison to drainage area) are generally experienced in watersheds with little NVS. Conversely, low flood discharges can indicate the presence of natural valley/flood plain storage. Caution must be taken when a discharge is labeled high or low. Watershed with extremely flat slopes or extensive storm drain storage systems may also experience low flow discharges. Low flood discharges can be caused by limited conveyance capability of the stream or limited storm drain capacity. Therefore, care as well as sound judgement must be taken when utilizing techniques presented in this report. Several other factors influence the watershed response to high runoff events and the availability of NVS chances. A short discussion of some of these factors is presented as follows:

- **Type of Flood,** NVS is more effective in the control of flash-type floods that result from high intensity short duration rainfall that peaks and recedes quickly, rather than long duration events when discharges remain high for a long period of time.

- **Antecedent Conditions,** such as saturation levels of storage areas, due to past floods or high runoff, determine the available volume of the storage areas. The greater the saturation level, the less effective a basin will be in providing available NVS.

- **Types of Soil** and their capacity to absorb rising water, influence runoff characteristics of the watershed.

- **Vegetated Surface Cover** such as a wetland or forest provides increase in evapotranspiration and retards water's movement, providing a better opportunity for NVS.

- **Flood Control Projects** and flow diversions, existing upstream of the site under study, may reduce peak discharges and volumes. Therefore, reduction to peak discharges, due to these projects, must be considered when evaluating experienced floodflows.

- **Heavily Developed Areas** produce high local runoff. Reduction in pervious land, as well as development of drainage systems, reduce available NVS.

Analysis for this study concentrated on recorded peak flows at USGS stations, and development of a curve relating net drainage area to peak discharge. Records from 31 USGS streamflow gages, with drainage areas ranging in size between 50 to 557 square miles, were selected for development. As part of the scope of work, gages with drainage areas smaller than 50 square miles were not included in this analysis. A map of USGS gage locations is shown in Figure 1.

The parameters used in this study (peak discharge and net drainage area) are relatively easy to obtain. Although techniques involving other parameters may be developed, they would involve some analysis, whereas the procedure presented in this report is based on a simple and hopefully effective approach for a first stage evaluation.

The use of regression equations may be useful for estimating peak discharges when they are not readily available. Regression equations for Massachusetts are found in the USGS Water Supply Paper 2214 entitled, "Estimating Peak Discharges of Small, Rural Streams in Massachusetts." The paper describes a method, using regression equations, to calculate peak discharges for specific regions of Massachusetts. The publication presents regression equations for three separate regions in the Commonwealth: eastern, central, and western. Parameters used in these equations are: drainage area, channel slope, storage area (e.g. swamps, lakes, ponds), and mean basin elevation. Stratified drift, which has been found to be a primary influence on peak discharges in other portions of New England (i.e., Connecticut), was not determined by USGS to be a major factor in their development of equations for Massachusetts. Another method to determine peak discharges when high watermarks and Flood Insurance information are available is detailed in section 4.c. of this report.

b. <u>Net Drainage Areas</u>. Major interbasin diversion facilities exist in the region connecting to the Massachusetts Water Resources Authority water supply system. The principal ones are Quabbin and Wachusett Reservoirs. The reduction in downstream flow due to these diversions, as well as other such as Worcester and Mother Brook, were included in the analysis. Numerous flood control projects are located throughout the State.

A map showing Corps of Engineers projects is shown in Figure 2. Some of these projects, namely flood control reservoirs, have a significant effect of floodflows in their watersheds. When analyzing gages in these watersheds, the impacts of flood control reservoirs were considered. Other flood control projects such as local protection projects can impact flood discharges by reducing available flood plain storage; however their impacts are considered minor for LPP projects in Massachusetts.

c. <u>Peak Discharge</u>. Information for six major storms affecting the Commonwealth of Massachusetts (March 1936, September 1938, August 1955, March 1968, June 1984, and March/April 1987) were used in the initial analysis and are shown in Table 1. In the interest of streamlining data and analysis, only the three major storms (March 1936, September 1938, and August 1955) were selected for development of the peak discharge/drainage area relationship. As shown in the isohyetal patterns for the selected storms (Figure 3), none of the storms affected the entire State uniformly. However, the selected storms are relatively consistent throughout the State. They were also considered representative of various storm types that affect NVS areas differently. The March 1936 storm was a large volume, long duration event, whereas the 1938, and, to a certain extent, the 1955 storms were of shorter duration, high intensity events, representing the flashy type flood.

These events were chosen for their storm sizes and relative uniformity throughout Massachusetts. The reader must keep in mind, however, that in some instances antecedent conditions and other factors, as previously mentioned in section 2.a., influence the basin NVS potential. A description of the three storms in Massachusetts follows:

(1) <u>March 1936</u>. Snowstorms and low temperatures, without the usual winter thaws, resulted in an unusually large snow accumulation. Rainfall totals from two major storms, during 9-22 March, were record maximums. During 9-13 March, 2 to 3 inches of rainfall occurred mostly in a 24-hour period. The rain, in combination with warm temperatures, melted the snow an ice cover, and released ice floes into river channels, causing flooding. Discharges on streams in the east and southeast peaked on 13-15 March. The 16-19 March storms produced an additional 1 to 8 inches of rain, which, combined with snowmelt runoff from the first storm, resulted in flooding in the remainder of the State from 18-20 March. According to the USGS, the flood was the largest in recorded history of the Connecticut and Merrimack Rivers in Massachusetts, as a result of runoff generated in upstream areas of these river basins outside of the State. The peak discharge of 16,300 cfs for the North Nashua River near Leominster (a tributary to the Merrimack River) exceeded the 100-year recurrence interval.

TABLE 1
MASSACHUSETTS GAGED BASINS FLOOD DATA

GAGED BASIN	DRAINAGE AREA			PEAK FLOWS						DRAINAGE AREA REDUCTIONS
	TOTAL	NET	NET(*)	1936 (cfs)	1938 (cfs)	1955 (cfs)	1968 (cfs)	1984 (cfs)	1987 (cfs)	
NASHUA RIVER - Fitchburg	63	63						2,740	3,510	
N. NASHUA RIVER - Leominster	110	110		16,300	10,300	8,870	4,070	5,900	7,400	
SQUANNACOOK RIVER - W. Groton	66	66				4,010	2,260	2,750	4,220	
NASHUA RIVER - E. Pepperell	435	316				4,250	3,620	1,780	2,580	Wachusett Reservoir
ASSABET RIVER - Maynard	116	116		20,900	10,200	5,880	6,900	6,820	11,700	
SUDBURY RIVER - Saxonville	106	84						1,250	2,240	
CONCORD RIVER Below Meadow Brook	400	307			3,790	4,540	4,800	4,010	5,120	Diversion for use by Boston Metropolitan District
IPSWICH RIVER - Ipswich	125	125		2,610	1,700		2,680	1,940	3,550	
CHARLES RIVER - Dover	183	183		3,170	3,110	3,220	3,220	2,310	2,770	Mother Brook Diversion
CHARLES RIVER - Wellesley	211	145					2,100	1,760	2,190	Mother Brook diversion
CHARLES RIVER - Waltham	251	185		2,540	2,180	2,490	2,670	2,410	2,710	Stony Brook and Mother Brook Diversion
TAUNTON RIVER - Bridgewater	258	258		3,020	2,480	4,010	4,980		3,530	
THREEMILE RIVER - N. Dighton	84	84					2,490	1,740	1,610	
BLACKSTONE RIVER - Northbridge	141	141		7,510		16,900				
FRENCH RIVER - Webster	84	31		**4,700		**14,400	1,000			Hodges Village and Buffumville Dams
MILLERS RIVER - Winchendon	82	82		5,530	8,500	731	1,200	3,500	4,000	
MILLERS RIVER - Erving	372	147		**19,700	**29,000	3,170	4,590	6,810	4,880	Birch Hill Dam and Tully Lakes
DEERFIELD RIVER - Rowe	254	254						3,340	20,400	
DEERFIELD RIVER - Charlemont	361	361		32,200	56,300	8,570	6,540	24,300	36,200	
NORTH RIVER - Shattuckville	89	89					5,040	10,500	14,200	
DEERFIELD RIVER - W. Deerfield	557	557				18,600	14,700	38,000	61,700	
MILL RIVER - Northampton	54	54				6,300	2,110	4,450	2,650	
WARE RIVER - Gibbs Crossing	197	142		**11,200	**22,700	**12,200	3,070	4,580	2,800	Barre Falls Dam
QUABOAG RIVER - W Brimfield	150	150		3,620	8,470	12,800	1,860	2,510	2,170	
CHICOPEE RIVER - Indian Orchard	689	500	445	**20,400	45,200	40,500	*6,500	*14,500	*6,680	Barre Falls Dam and Quabbin Reservoir
W. BRANCH WESTFIELD - Huntington	94	94		14,400	21,800	26,100	4,570	13,200	13,900	
WESTFIELD RIVER - Westfield	497	335	283	**48,200	*55,500	70,300	*8,110	*14,200	*21,200	Knightville Dam and Littleville Dam
W. BRANCH FARMINGTON - N. Boston	92	92		9,080	18,500	34,300	2,290	7,740	8,630	
HOUSATONIC RIVER Gt. Barrington	282	282		8,990	11,520	6,060	3,460	10,300	6,050	
GREEN RIVER - Gt. Barrington	51	51				1,060	1,360			
HOOSIC RIVER - Williamstown	126	126				3,070	3,750	4,670	9,350	

* Net drainage area reduced by more than one flood control reservoir.
** Total drainage area was used to plot these values

(2) <u>September 1938</u>. A stationary cold front along the Atlantic coast was overrun by a rapidly moving tropical hurricane, producing record breaking rainfall over large areas of central and western Massachusetts. The arrival of the ocean storm wave associated with floodflows, and the September 1938 hurricane at high tide, caused extreme tidal stages in Buzzards Bay and southern Cape Cod. Total rainfall exceeded 10 inches in central Massachusetts. A maximum of nearly 17 inches occurred along the eastern edge of the Connecticut River Basin at Barre. According to the USGS, this storm resulted in the second largest flood in some basins, and in various places exceeded discharges of the 1927 and 1936 events for many tributaries in central Massachusetts. The USGS reported peak discharge of 3,000 cfs for Priest Brook near Winchendon was about two times the 100-year recurrence interval. In the Housatonic River near Great Barrington, the 1938 event was exceeded only by the 1949 flood.

(3) <u>August 1955</u>. During the month of August 1955, New England was struck by two tropical storms, "Connie" and "Dianne." Hurricane "Connie" ended an extended dry spell. During 11-16 August, total rainfall ranged from 2 to 9 inches. This storm was followed by 2 to 19 inches of rainfall from hurricane "Dianne" during 17-20 August. According to the USGS, this storm is the most severe recorded in New England, with respect to precipitation, intensity magnitude, and distribution. The most damaging floods occurred from the Blackstone River west to the New York State line. Recurrence intervals in this area ranged from 5 years to greater than 100 years. Flooding in the Housatonic River Basin, near Great Barrington to the west, was relatively minor (6,060 cfs). In the Westfield River Basin, where maximum rainfall measured 20 inches, high flows were generated along the main stem downstream from Knightville Dam, and in the southern part of the basin.

d. <u>Curve Development</u>. Using the information previously described (net drainage area and peak discharges for three major storms) a peak discharge/drainage area graph was developed, as shown in Figure 4.

The three zones in the graph were determined principally from hydrologic engineering judgement with a **"little to none"** zone representing watershed with high experience peak discharges and, therefore, little available flood plain storage. On the other extreme, the **"significant"** zone has relatively low experienced discharges and considerable available storage. The middle zone **"moderate"** is the largest, and considerable judgement must be used if a watershed falls in this zone. A point closer to the "significant" zone might indicate potential for NVS; whereas, a point closer to the "little to none" zone indicates less potential storage. The lines limiting these zones were determined following the criteria that flows in the range of 40 to 50 csm or less, represent significant NVS for major flood events while flows in the range of 90 to 100 csm represent little to no NVS.

Table 2 was developed to present NVS potential results for the gaged basins compiled in Table 1. Peak discharge information for the six storms analyzed was plotted, and potential NVS was estimated. A detailed description of NVS screening technique usage for gaged and ungaged basins follows.

3. APPLICATION OF TECHNIQUE FOR GAGED BASINS

The principal source of streamflow data is the USGS with over 85 gages presently operating in the Commonwealth of Massachusetts. Discharge records of existing stations are compiled and published annually by USGS. Figure 1 shows location of the gages in operation at the present time. Additional data on existing and discontinued gages can be obtained, using other sources of information such as HYDRODATA compact discs by Hydrosphere, Inc., or similar data available on compact discs supplies by Earthinfo, Inc.

a. Obtain peak discharge in cubic feet per second (cfs) from the USGS or other sources for a major event. We recommend using peak discharges for the March 1936, September 1938, or August 1955 storms if available.

b. Determine (in square miles) the drainage area of the stream to be analyzed at the point where the peak discharge is estimated. If major flood control or other storage reservoirs have been constructed, then their effects must be considered and perhaps the drainage area be reduced by the drainage area controlled by the storage reservoir.

c. Plot net drainage area (sm) versus peak discharge (cfs) in Figure 4.

d. If the value falls in the "significant" zone or lower region of the "moderate" zone, the river basin may have enough NVS to warrant further analysis.

4. APPLICATION OF TECHNIQUE FOR UNGAGED BASINS

Natural Valley Storage in ungaged basins can be evaluated in some cases where limited information is available.

a. Determine net drainage area of the stream at a point of interest. If not available, this information can be obtained by delineating the watershed area upstream from the site of interest on 7.5 or 15-minute USGS topographic quadrangle maps, and then by planimetering the basin area. Watershed areas, regulated due to flood control or large storage reservoirs, should be subtracted from total area of the basin.

TABLE 2

POTENTIAL NATURAL VALLEY STORAGE FOR MASSACHUSETTS GAGED BASINS *

GAGED BASIN	N V S EFFECT 1936 (cfs)	1938 (cfs)	1955 (cfs)	1968 (cfs)	1984 (cfs)	1987 (cfs)	POTENTIAL NATURAL VALLEY STORAGE
NASHUA RIVER - Fitchburg					m	m	Moderate
N. NASHUA RIVER - Leominster	l	m	m	m	m	m	Moderate
SQUANNACOOK RIVER - W. Groton			m	m	m	m	Moderate
NASHUA RIVER - E. Pepperell**			s	s	s	s	Significant
ASSABET RIVER - Maynard	l	m	m	m	m	m	Moderate
SUDBURY RIVER - Saxonville**					s	s	Significant
CONCORD RIVER - Meadow Brook		s	s	s	s	s	Significant
IPSWICH RIVER - Ipswich	s	s		s	s	s	Significant
CHARLES RIVER - Dover	s	s	s	s	s	s	Significant
CHARLES RIVER - Wellesley				s	s	s	Significant
CHARLES RIVER - Waltham	s	s	s	s	s	s	Significant
TAUNTON RIVER - Bridgewater	s	s	s	s		s	Significant
THREEMILE RIVER - N. Dighton				s	s	s	Significant
BLACKSTONE RIVER - Northbridge	m		l				Moderate to Little
FRENCH RIVER - Webster**	m		l	s			Undefined
MILLERS RIVER - Winchendon	m	m	s	s	s	m	Signif to Moderate
MILLERS RIVER - Erving**	m	m	s	s	s	s	Signif to Moderate
DEERFIELD RIVER - Rowe					s	m	Undefined
DEERFIELD RIVER - Charlemont	m	l	s	s	m	l	Undefined
NORTH RIVER - Shattuckville				m	l	l	Moderate to Little
DEERFIELD RIVER - W. Deerfield			s	s	m	l	Undefined
MILL RIVER - Northampton			l	m	m	m	Moderate to Little
WARE RIVER - Gibbs Crossing**	m	l	m	s	s	s	Signif to Moderate
QUABOAG RIVER - W Brimfield**	s	m	m	s	s	s	Signif to Moderate
CHICOPEE RIVER - Indian Orchard**	s	m	m	s	s	s	Signif to Moderate
W. BRANCH WESTFIELD - Huntington	l	l	l	m	l	l	Little to Moderate
WESTFIELD RIVER - Westfield**	l	l	l	s	m	m	Little to Moderate
W. BRANCH FARMINGTON - N Boston	m	l	l	s	m	m	Little to Moderate
HOUSATONIC RIVER - Great Barrington	s	s	s	s	s	s	Significant
GREEN RIVER - G. Barrington			s	s			Significant
HOOSIC RIVER - Williamstown			s	s	s	m	Signif to Moderate

* Gages larger than 50 square miles

** Watershed with significant upstream water supply or flood control reservoirs

NOTE: Gages with no information available are not included.

b. Obtain peak discharge estimates in cfs for a given storm event such as the March 1936, September 1938, or August 1955 storms. This information can be obtained from hydrologic studies performed in the river basin. If peak discharges are available, follow steps "c" and "d" in paragraph 3.

c. When peak discharges are not available, other sources of information (such as high watermarks) can be used in combination with flood profiles from Flood Insurance or hydrologic studies. A rating curve can be developed from flood profile information. Using the rating curve and the elevation associated with the high watermarks, the peak discharge (cfs) can be estimated. An example of this technique is illustrated in Appendix A.

d. Follow steps "c" and "d" in paragraph 3.

5. SUMMARY

Techniques in this report provide a means for estimating potential NVS on streams within the Commonwealth of Massachusetts. The relationship of peak discharge versus net drainage area can be used in the initial screening efforts for a given basin.

6. REFERENCES

a. National Water Summary 1988-89, Hydrologic Events and Flood and Droughts, U.S. States Geological Survey, Water Supply Paper 2375.

b. Hydrodata, USGS Daily and Peak Values, 1990, Version 2.1, Hydrosphere, Inc., Boulder, CO.

c. Project Maps, September 1984, Flood Control New England Division, Corps of Engineers, Waltham, MA.

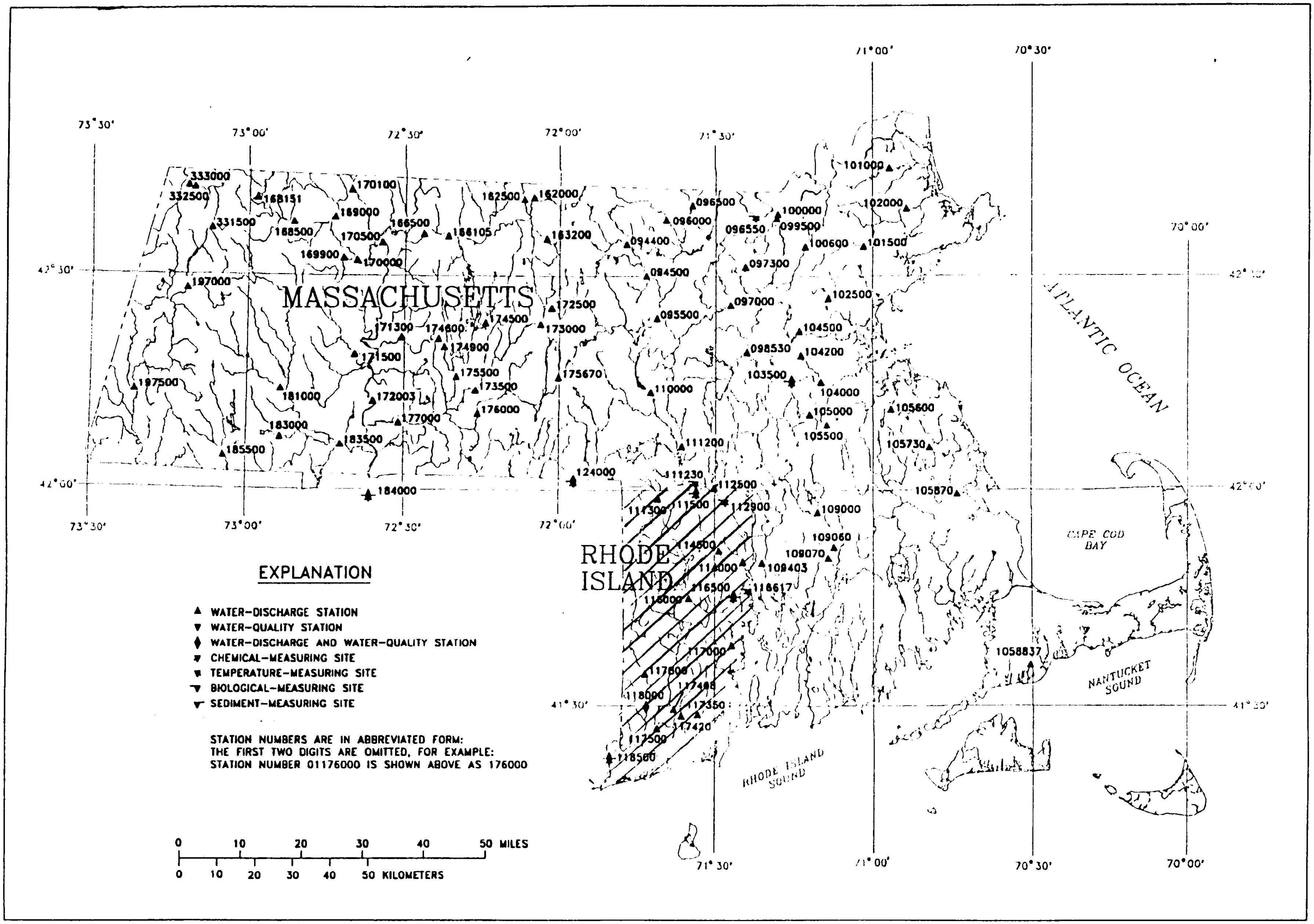
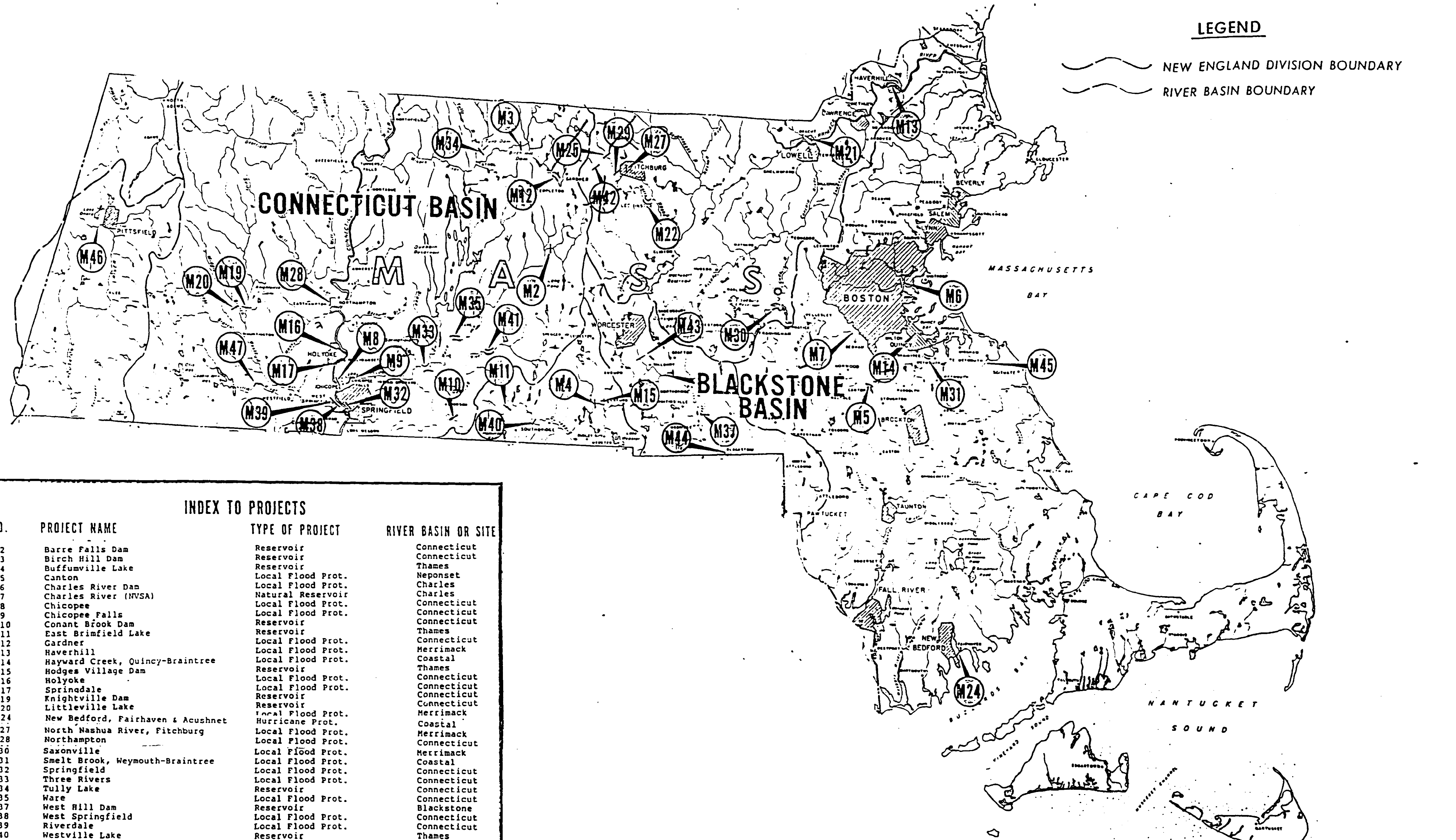


Figure 1.--Location of gaging-stations.



INDEX TO PROJECTS

NO.	PROJECT NAME	TYPE OF PROJECT	RIVER BASIN OR SITE
M2	Barre Falls Dam	Reservoir	Connecticut
M3	Birch Hill Dam	Reservoir	Connecticut
M4	Buffumville Lake	Reservoir	Thames
M5	Canton	Local Flood Prot.	Neponset
M6	Charles River Dam	Local Flood Prot.	Charles
M7	Charles River (NVSA)	Natural Reservoir	Charles
M8	Chicopee	Local Flood Prot.	Connecticut
M9	Chicopee Falls	Local Flood Prot.	Connecticut
M10	Conant Brook Dam	Reservoir	Connecticut
M11	East Brimfield Lake	Reservoir	Thames
M12	Gardner	Local Flood Prot.	Connecticut
M13	Haverhill	Local Flood Prot.	Merrimack
M14	Hayward Creek, Quincy-Braintree	Local Flood Prot.	Coastal
M15	Hodges Village Dam	Reservoir	Thames
M16	Holyoke	Local Flood Prot.	Connecticut
M17	Springdale	Local Flood Prot.	Connecticut
M19	Knightville Dam	Reservoir	Connecticut
M20	Littleville Lake	Reservoir	Connecticut
M24	New Bedford, Fairhaven & Acushnet	Local Flood Prot.	Merrimack
M27	North Nashua River, Fitchburg	Hurricane Prot.	Coastal
M28	Northampton	Local Flood Prot.	Merrimack
M30	Saxonville	Local Flood Prot.	Connecticut
M31	Smelt Brook, Weymouth-Braintree	Local Flood Prot.	Merrimack
M32	Springfield	Local Flood Prot.	Coastal
M33	Three Rivers	Local Flood Prot.	Connecticut
M34	Tully Lake	Local Flood Prot.	Connecticut
M35	Ware	Reservoir	Connecticut
M37	West Hill Dam	Local Flood Prot.	Connecticut
M38	West Springfield	Reservoir	Blackstone
M39	Riverdale	Local Flood Prot.	Connecticut
M40	Westville Lake	Local Flood Prot.	Connecticut
M41	West Warren	Reservoir	Thames
M43	Worcester Diversion	Local Flood Prot.	Connecticut
M44	Blackstone River, Blackstone	Local Flood Prot.	Blackstone
M45	Bound Brook, Scituate	Local Flood Prot.	Blackstone
M46	Housatonic River, Pittsfield	Snag and Clear	Coastal
M47	Little River Dike, Westfield	Local Flood Prot.	Housatonic
		Local Flood Prot.	Connecticut

A T L A N T I C   O C E A N

INDEX MAP
FLOOD CONTROL PROJECTS

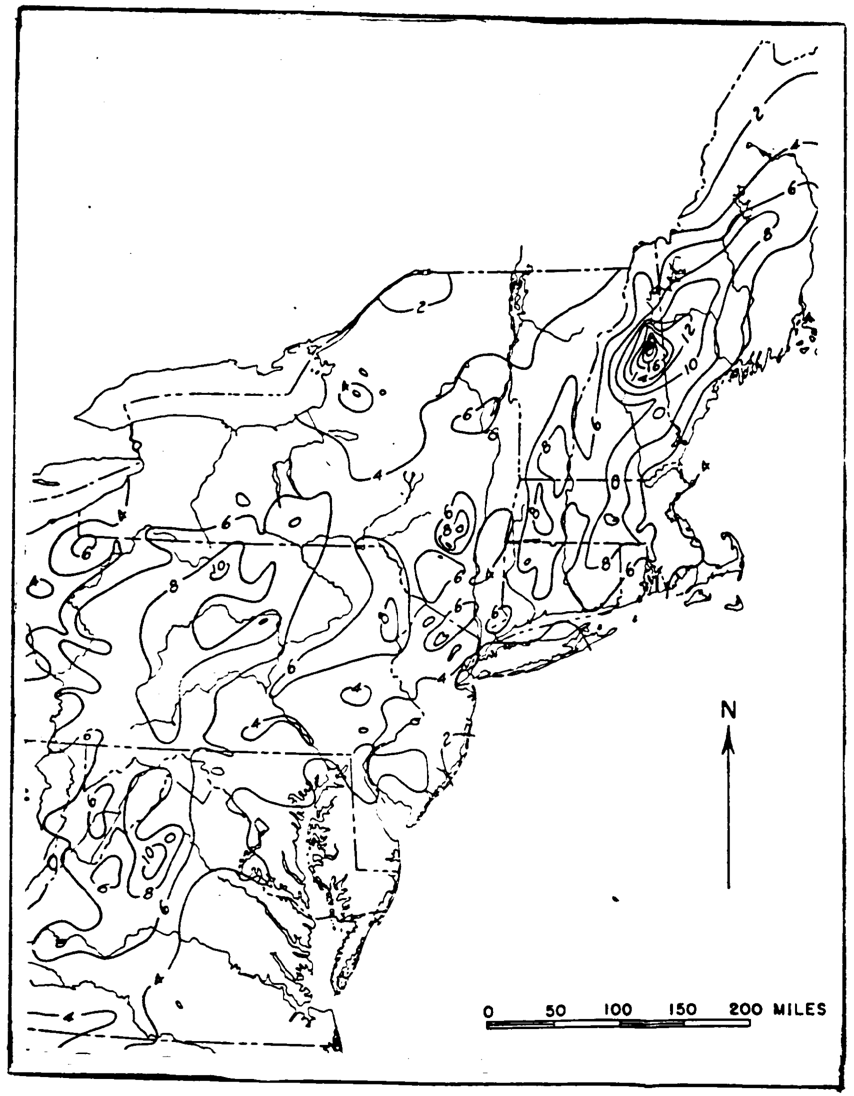
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

SCALE IN MILES
8 0 8 10 24

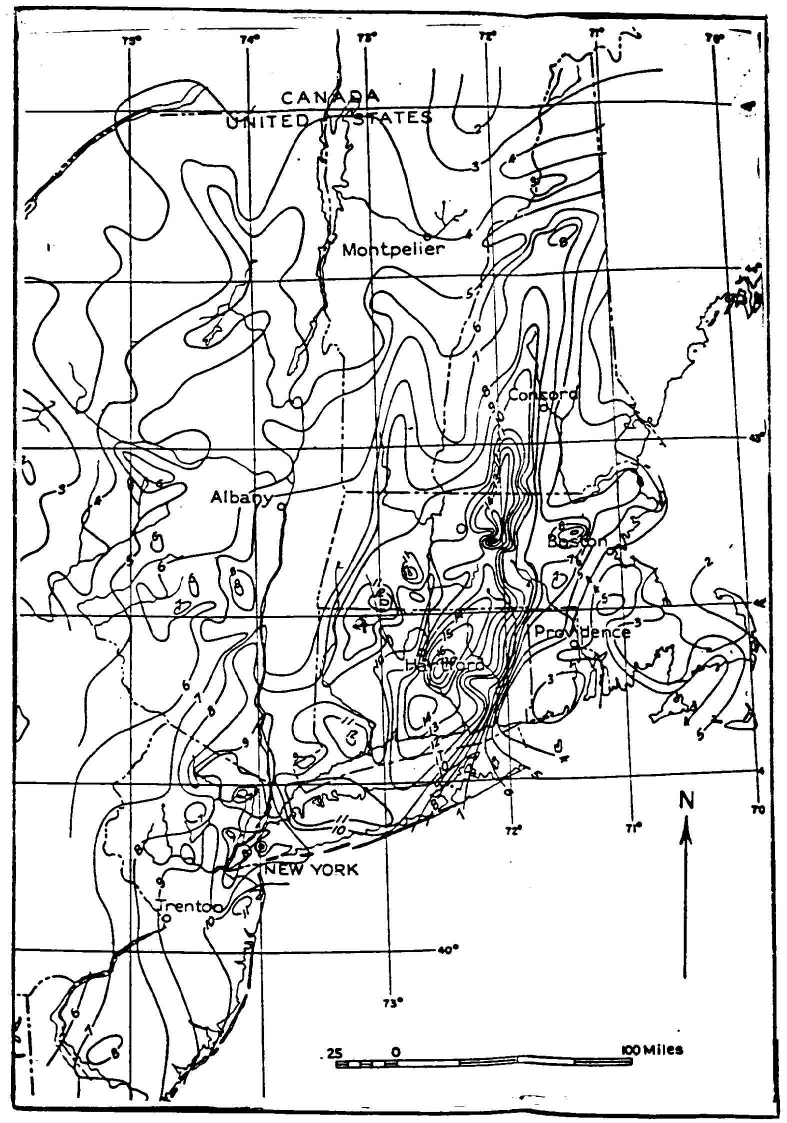
30 SEPTEMBER 1984

Figure 2

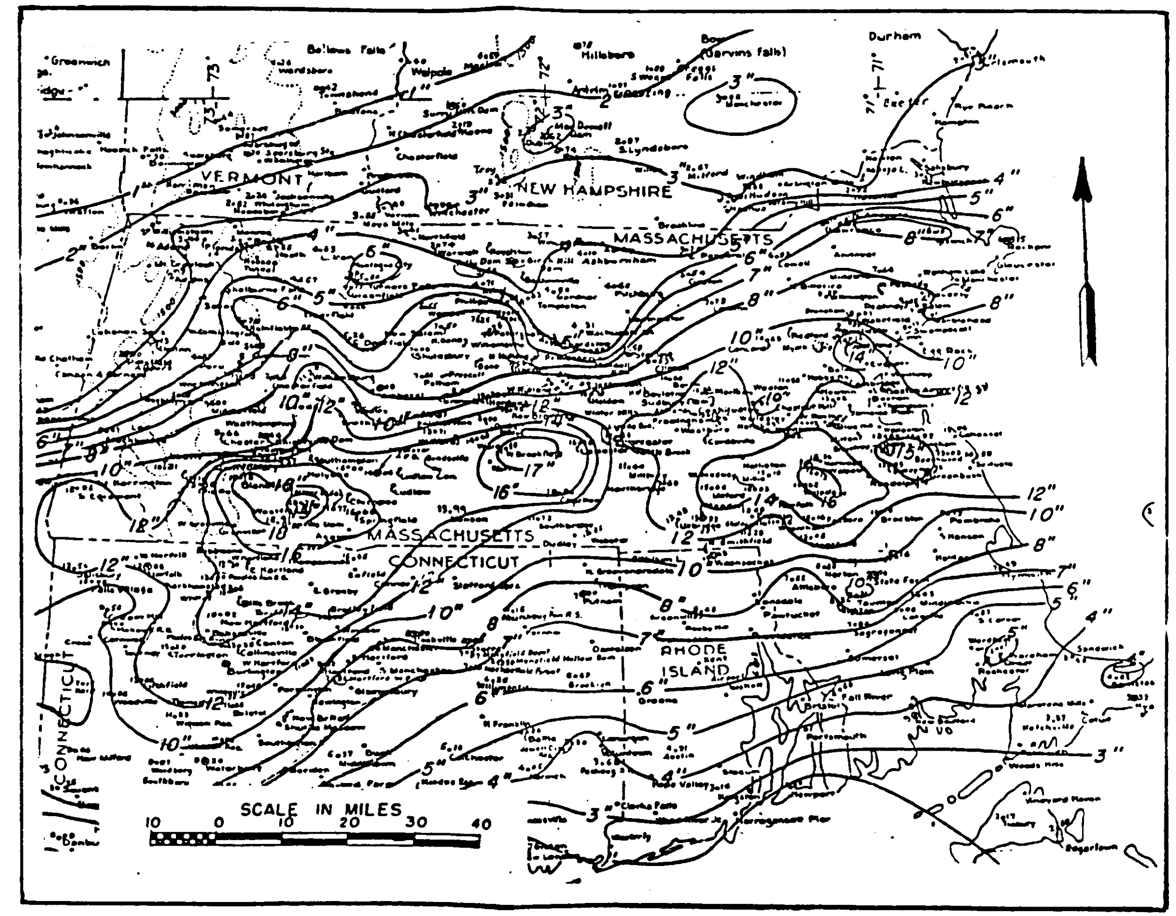
STORM OF MARCH 9 - 22, 1936



STORM OF SEPTEMBER 17 - 21, 1938



STORM OF AUGUST 17 - 20, 1955

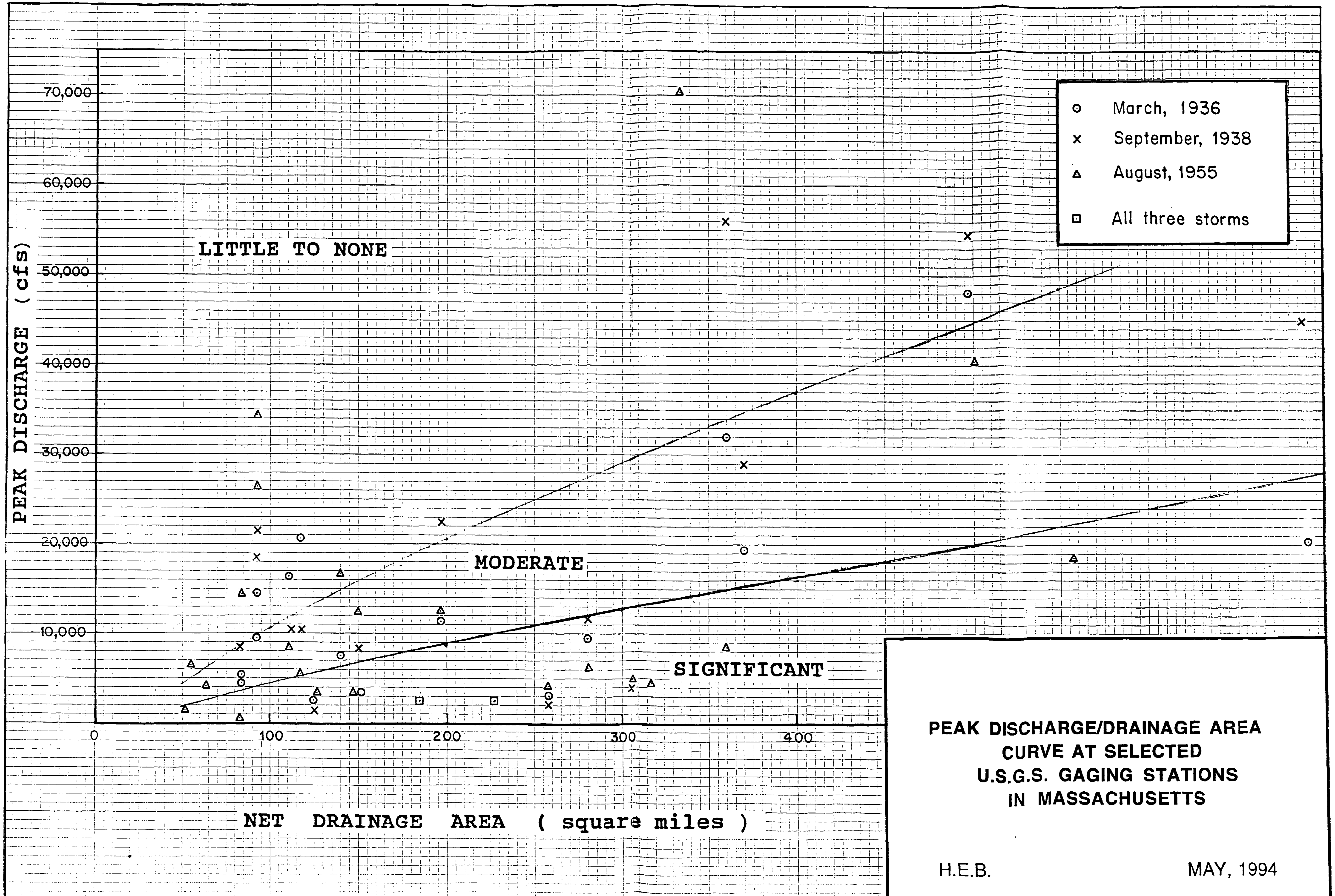


MASSACHUSETTS NATURAL VALLEY STORAGE INVESTIGATION

Isohyetal Maps For Selected Storms Showing Total Precipitation In Inches

HEB **June 1996**

Figure 3



PEAK DISCHARGE (cfs)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
100
200
300
400
NET DRAINAGE AREA (square miles)
LITTLE TO NONE
MODERATE
SIGNIFICANT
March, 1936
September, 1938
August, 1955
All three storms
PEAK DISCHARGE/DRAINAGE AREA
CURVE AT SELECTED
U.S.G.S. GAGING STATIONS
IN MASSACHUSETTS
H.E.B.
MAY, 1994

FIGURE 4

APPENDIX A

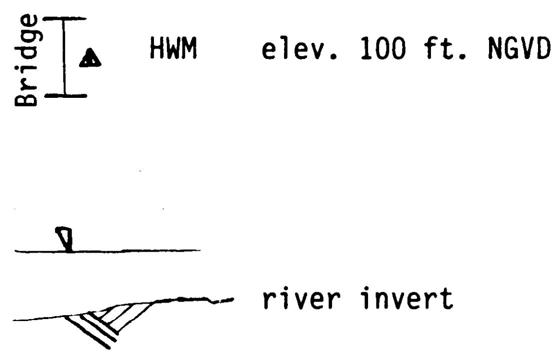
EXAMPLE OF AN UNGAGED WATERSHED

SUBJECT MASSACHUSETTS NATURAL VALLEY STORAGE INVESTIGATION

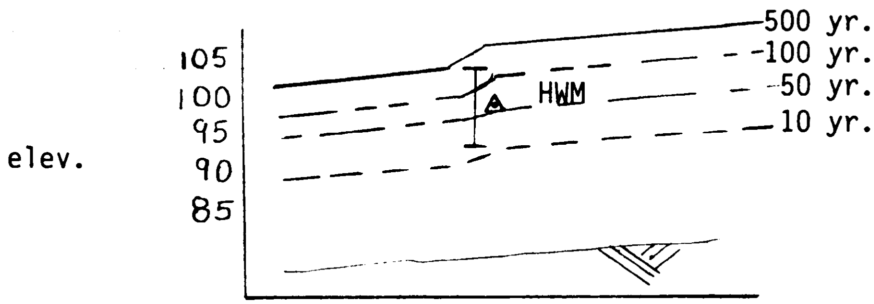
COMPUTATION Example for Non Gaged Watersheds

COMPUTED BY ________ CHECKED BY ________ DATE ________

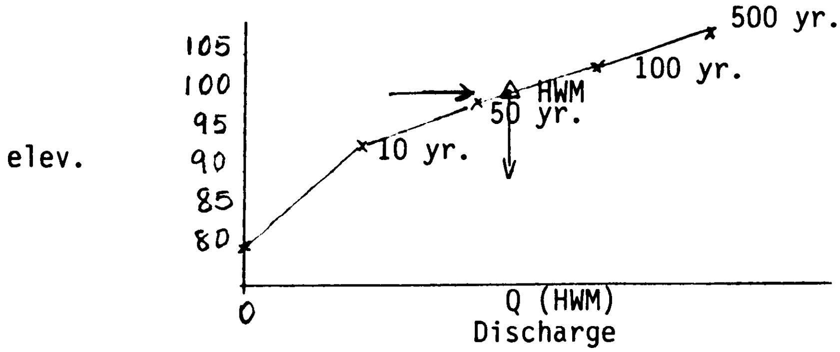
Step # 1 Locate a known historic high water mark (HWM). A surveyed elevation would be desirable. However, if not available use an estimate.



Step # 2 Obtain flood profile information from available sources such as flood insurance studies (FIS).
Determine discharges used to compute profiles (i.e. FIS report, etc)



Step # 3 From information in Step 2 plot discharge rating curve. Locate HWM in the rating curve.



SUBJECT MASSACHUSETTS NATURAL VALLEY STORAGE INVESTIGATION

COMPUTATION Example for Non Gaged Watersheds

COMPUTED BY ____ CHECKED BY ____ DATE ____

Step # 4

From discharge rating curve in step 3 determine discharge (Q) corresponding to HWM.

If discharge appears to represent a significant event (i.e. greater than 10 yr. frequency)determine the drainage area (DA) and enter in fig. 3 with its corresponding Q.

If Q is less than estimated 10 yr. event try to locate additional high water mark information and repeat process.